The polar ring galaxy AM 2040-620 and its possible companion

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Polar ring galaxies (PRGs) are peculiar systems where a gas-rich, nearly polar ring surrounds a host galaxy. They are the result of galaxy interactions that form mainly by tidal accretion of material from a gas rich donor galaxy. There is a number of formation mechanisms for PRGs: minor or major mergers, tidal accretion events, or direct cold gas accretion from filaments of the cosmic web. These objects can be used to probe the three-dimensional shape of dark matter haloes, provided that the ring is in equilibrium with the gravitational potential of the host galaxy. The polar ring galaxy, AM 2040-620, which has not yet been well studied, is the subject of this work. This galaxy contains an almost perpendicular warped ring and one possible companion galaxy to the NW. The radial velocity of this object is 3301±65 Km s^{-1} and is part of a group of fifteen possible polar ring galaxies, according to the literature. In order to better understand this system, images and long slit spectra were observed with the 1.60 m OPD/LNA telescope. In the I band image, the outer parts of the ring are not symmetrical. A disturbance in the Eastern side and a faint plume were detected. Two small satellites are located to the north. The bulge is elliptical but not perfectly symmetrical in this image. The B-band image shows material that extends beyond the ring in the western and eastern directions. After processing, the B-image shows that the possible companion galaxy 2MASX J20441668-6158092 has a tidally disturbed disk. Its radial velocity is unknown, but the spectroscopy, which is still under analysis, will furnish this information.

I. INTRODUCTION

Polar ring galaxies (PRGs) constitute a rare class of interacting systems and consist of an early-type, lenticular, elliptical or even spiral host galaxy, surrounded by a ring of gas, dust and young stars orbiting in a nearly polar plane (e.g. [1], [2], [3], [4], [5]).

In these objects, the velocities of the ring and the host galaxy are quite close, with an almost balanced state. The ring material appears to be in regular rotation about the galaxy center (e.g. [6], [7], [8]) and is presumably stabilized in some way. According to Iodice (2002) [9], for a PRG to become stable, the formation of the ring must follow a certain logic, in which the ring size is strongly related to the amount of matter in the host galaxy (visible + dark).

The presence of two almost perpendicular angular momentum vectors cannot be explained through the collapse of a single protogalactic cloud; therefore a "second event" must have occurred in the formation history of these objects. However, no one knows for sure how these objects are formed. There are three formation mechanisms for PRGs [10]: minor or major mergers, tidal accretion events or direct cold gas accretion from cosmic web filaments. These objects can be used to probe the three-dimensional shape of dark matter haloes, provided that the ring is in equilibrium with the gravitational potential of the host galaxy.

In this paper, we study the PRG AM 2040-620. The galaxy has an elliptical bulge. Its with radial velocity is 3301±65 km s^{-1} (this paper), very similar (within the errors) to the value measured from HI data by van Driel (2002) [11] (3335±24 km s^{-1}). The ring is not radially thick and presents a warped appearence.

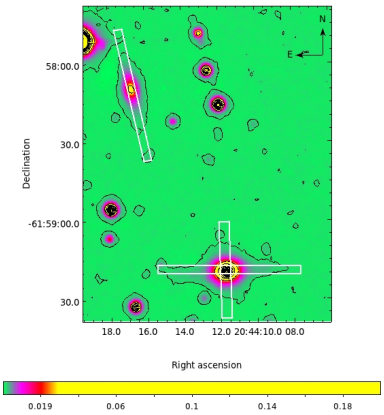

Figure 1: B-band image of NGC 5122 with slit position.

II. OBSERVATIONS AND REDUCTIONS

Broad band imagery was carried out with the 1.6-m telescope at the OPD (MCT/LNA), Brazil. The telescope was equipped with direct imaging camera♯1 with CCD♯106 (1024x1024 square pixels). The data were acquired with standard Johnson U, B, V, R and I filters.

Long slit spectroscopy was done a with the same telescope equiped with a Cassegrain spectrograph and CCD♯105 (2048x2048 square pixels). During the observations, we used grating of 600 lines mm^{-1}, centered at 5800Å. We took three slit positions (see Figure 1): (1) along the ring (0°); (2)along the galaxy's major axis (host) (88°); and (3) along the companion galaxy's major axis (77°). CCD data reduction was performed in the standard manner using IRAF (*Image Reduction and Analysis Facility*) package. HeAr lamps were measured before and after each exposure in order to provide accurate wavelength calibration. The spectra were flux calibrated using standard stars observed at similar airmasses.

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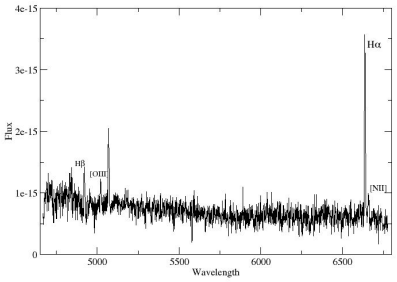

Figure 2: Companion Galaxy Spectra.

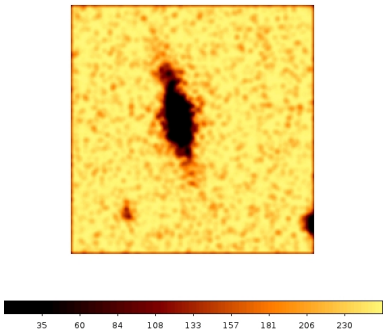

Figure 3: B-band image of companion galaxy. With possible tidal disturbances.

III. RESULTS

The host galaxy of this system is surrounded by a nearly polar ring (inclined 88°). The eastern region of the system has some traces of perturbation and tide. R-band image shows an elliptical bulge, which is not completely symmetrical, with some strains principally in NE and SW. There are two small satellites to the SE. We measured its radial velocity as 3301±65 km s^{-1}, value close to the literature [11].

The ring has a wavy behavior. At the extremes of the ring is low surface brightness leftover material. This material may be a remnant of the interaction process that originated the ring.

Figure 2 shows the spectrum of the companion galaxy of the system, where the main lines of the system are marked. Many PRGs have companions, because they are often the donors of material for the formation of the ring. AM 2040-620 is a galaxy in the NW, which had hitherto unknown speed. After our observations, we measure its radial velocity as 3331± 47 Km s^{-1}, which is very close to that of the PRG. These results indicate that these galaxies are possibly part of a group, which went through a process of interaction that resulted in the formation of the ring. Image B, processed through a square 50×50 pix^2 kernel, and subtracted from the original image, is shown in Figure 3. It highlights high frequency structures, making more evident the warped outer parts of the disk, and suggesting a tidal origin. There is no bridge or material that binds the rest of this interacting galaxy system.

IV. CONCLUSIONS

This work allows us to conclude that this system is a galaxy with polar ring, which has a companion galaxy with visible deformities, possibly due to the effects of the interaction process. A bridge or tails interconnect the PRG. The ring is corrugated and symmetrical. The host galaxy is elliptical and has some deformities.

V. ACKNOWLEDGEMENTS

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